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DRILLING IN STONE WITHOUT METAL.

BY CHARLES RAU.

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DRILLING IN STONE WITHOUT METAL.

BY CHARLES RAU.

Some archaeologists, among them Sir John Lubbock, incline to the opinion that the perforated stone axes and hammers which have been found in Europe are to be referred to the beginning of the bronze period. Many of those implements doubtless belong to the age of bronze; they have frequently been discovered in connection with bronze articles in ancient graves, and it is, moreover, well known that the manufacture and use of stone weapons and implements were everywhere continued for a long time after the introduction of bronze. These facts, however, furnish no evidence for ascribing pierced stone implements generally to the period in which the use of bronze was already known; in many cases, on the contrary, it may be inferred from the nature of their finding-places, as well as from the character of their perforations, that they belong to the stone age proper. In the illustrated catalogue of the collection in the Copenhagen museum, edited by Mr. J. J. A. Worsaae,* there are eleven representations of pierced stone implements attributed to the age of stone, and the foremost objects, figured to illustrate the bronze period, consist of seven perforated stone axes, distinguished by elegant shape and superior workmanship. Though I am not acquainted with the particular circumstances of the discovery of these implements, I have not the least doubt that the learned editor of the catalogue, in referring them respectively to the ages of stone and bronze, based his classification on tenable grounds.

A number of those lacustrine pile-works, which pertain exclusively to the stone age, have yielded stone axes and hammers, as, for instance, the station of Nussdorf, on the Lake of Ueberlingen, (an arm of the Lake of Constance) where no less than fifty have been found. Mr. Desor, on whom I rely for these facts, also mentions that in another lacustrine station of the stone age the articles in question are confined to the upper part of the "archæological stratum," that is, the stratum which contains relics of art. Pierced implements, therefore, would seem to belong, in those localities at least, to a later epoch of the stone age, and thus to mark a phase of progress in the gradual development of human skill during that period.†

After a careful examination and comparison of the shaft-holes of European stone implements, I have arrived at the conclusion that two different methods, or, at least, two differently shaped drills were employed in making them. The more perfect perforations are of equal width, smooth and shining, and exhibit at certain distances circular striæ or furrows, which have the appearance of a succession of parallel rings. These perforations, I think, have been drilled with a hollow cylinder, perhaps a bronze tube, and I believe that the implements pierced in the manner described were mostly manufactured during the age of bronze. They are, moreover, very often remarkable for elegance of outline and high finish, indicating a state of art superior to that which is generally supposed to have existed in Europe during the period of stone. In other specimens the

* Worsaae, *Nordiske Oldsager i det Kongelige Museum i Kjøbenhavn*, 1859.

† Desor, *Palafittes, or Lacustrine Constructions of the Lake of Neuchâtel*; *Smithsonian Report for 1863*, p. 359, (note.)

shaft-holes are likewise more or less smooth, but destitute of the annular striae, and sometimes narrower in the middle, in which cases, of course, a circular protuberance of corresponding size is formed. (Fig. 1.)

Fig. 1.



These holes evidently were drilled from two sides, and the drilling implement was not a hollow cylinder, but a solid body, probably a wooden stick. Most of the axes and hammers provided with shaft-holes of this character are perhaps relics of the age of stone. It is hardly necessary to state that without the application of water and hard sand, drilling with either implement, hollow or solid, would have

been impossible, and that the sand is to be considered as the chief agent in the process.

I had occasion to examine a number of European stone hatchets and hammers, which were in an unfinished state, the shaft-holes being only commenced or drilled half through, and the appearance of the latter perfectly corroborated my view concerning the different shapes of the drills used in making them; for some of these unfinished holes, and just such as belong to the striated class, have at the bottom a conical projection or a core, (Fig. 2,) which obviously resulted from

Fig. 2.



Fig. 3.



the application of a hollow drilling implement; while others (Fig. 3) terminate in a rounded concave bottom, resembling exactly the cavity made by a wooden stick used as a drill.* I would not express this latter

opinion so positively, if I could not rely on the results of experiments, having, in fact, succeeded in perforating a hard stone without any use of metal by means of a stick, in connection with sand and water. An account of the method employed by me, and of the results, I hope will be of interest to those archaeologists who pay some attention to the minor details of their study.

In the first place, I will give a description of my drilling implement, (Fig. 4,) which is, in fact, a pump-drill, the same apparatus that was used in former times by the Iroquois for the purpose of producing fire by friction.† It consists of a round wooden shaft, about four feet long and an inch in diameter at the upper end, but tapering a little towards the lower extremity, where it is provided with a heavy wooden disk, which acts as a fly-wheel. A bow or bent stick, three feet in length, with a long string attached to it, forms the second part of the apparatus. When used the string of the bow is passed through a notch cut in the top end of

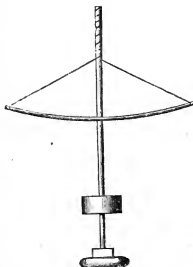
* It afforded me some satisfaction to find my views confirmed, to a certain extent, in a work of Dr. Gustav Klemm. This author first alludes to Gutsmuths, who published an article in the "*Morgenblatt*," (1832, No. 253,) in which he tried to prove that a hollow cylinder of metal, used with emery in the manner of toothless stone saws, was the drilling implement of the ancients, basing his opinion upon the same facts which I already have stated, namely, the regularity of the holes, the core at their bottom, and the circular furrows. Klemm himself possessed in his collection a hollow bronze tube, five inches long, three-quarters of an inch in diameter, and covered all over with green rust, the *ergo nobilis* of antiquaries. With such implements, he thought, the shaft-holes had generally been drilled, "but continued observation," he says, "convinced me that other methods also must have been employed. A stone axe of my collection, bored from two sides, exhibits conical cavities, the shape of which at once excludes the idea that a hollow cylinder was used in drilling them; the implement with which they were made, probably in a slow and painful way, evidently was a solid body." (Klemm, *Allgemeine Culturwissenschaft, Werkzeuge und Waffen*, Leipzig, 1854, p. 79.)

† Morgan, *League of the Iroquois*, Rochester, 1851, description and figure on page 381. Mr. Tylor gives likewise, on page 245 of his valuable "*Researches into the Early History of Mankind*," (London, 1865,) a drawing of the apparatus, but represents it as being moved with one hand only. In order to maintain the equilibrium of the shaft, it is necessary to apply both hands to the bow.

the stick and coiled around the stick, as indicated in the drawing. The bow is then seized with both hands and pressed downwards with a violent jerk. This motion uncoils the string and revolves the shaft towards the left, but by the action of the fly-wheel the string is coiled again around the shaft in a reverse manner, and the bow drawn up again. A second jerk at the bow causes the shaft to revolve towards the right, and by continuing this manipulation it is alternately swung around in opposite directions. The operator has it altogether in his power to work the apparatus slowly or rapidly, and, of course, with corresponding effect; but it requires some practice to use it in the proper manner.

The stone selected by me for the experiment is a flat, oval piece of diorite, of great hardness, not quite seven inches long, about five inches wide, and in the middle part one inch and three-eighths (a little over 3.5 centimeters) thick. I chose purposely that kind of stone, because it is the same of which the ancient inhabitants of Europe very often made their pierced implements. It is both hard and tough. These qualities were likewise appreciated by the North American aborigines, who used diorite extensively as the material for their tomahawks, large chisels, and pestles. The stone on which I operated is so hard that the point of a well-tempered penknife produces no scratch on its surface, but merely a metallic streak. The material used in drilling was a sharp quartz sand of middle grain, such as is employed in marble-yards; for a short time I also tried emery, but finding that it was not more effectual than sand, I continued to apply the latter. In order to render a beginning of the perforation possible, I tied a small square piece of board in which I had cut a round hole, corresponding to the lower diameter of the drilling-stick, with a string to the stone, just above the place where the bore was to be commenced. Without this contrivance, which I had to retain during the whole drilling process, the stick would constantly have slipped out of the hole. After these preparations I could begin the work, which was not very fatiguing, but tedious beyond description, taxing, in fact, my patience to the utmost degree. I never could endure the work for more than two hours in succession, and sometimes I laid the stone aside for weeks and months, until I had mustered sufficient energy to resume the labor. Thus it took two years before I succeeded in piercing the stone. I cannot exactly state how many hours I devoted to the work, but by measurement I obtained the result that two hours of constant drilling added, on an average, not more than the thickness of an ordinary lead-pencil line to the depth of the hole. The work would have advanced with incomparably greater speed, if I had selected a softer stone, serpentine, for instance, instead of the hard diorite; it was, however, my object to try the experiment on a hard mineral substance. Every five or six minutes the bore had to be cleaned by immersing the stone in water, the sand being by that time perfectly ground, and forming, in connection with the water and the particles of wood rubbed from the stick, a sort of paste, which was no longer serviceable for drilling. The quantity of sand introduced after every cleaning was about equal to the contents of a teaspoon. The shortening of the drilling-stick,

Fig. 4.



in consequence of wear, was considerable, and I had to replace it several times. The first was of tough ash wood; the others, which consisted of pine wood, proved to be just as efficient.

In the beginning of the work there appeared at the place of perforation a smooth, round spot. Becoming gradually larger, it formed a shallow basin, which finally, when the stone was drilled half through, assumed the appearance of a conical or funnel-shaped cavity. The deeper the drill penetrated into the stone the more difficult the work became, which induced me, after having drilled through half the thickness of the stone, to begin another bore at the opposite side. In due time it met the first exactly in the middle. It was originally my intention to drill a hole of about three-quarters of an inch in diameter, but I had not made sufficient allowance for the lateral friction of the sand, and hence it happened that the two conical cavities forming the perforation acquired, much against my wish, greater proportions than I expected, measuring, in fact, an inch and a quarter in their widest diameters. They would have become narrower as well as more cylindrical, if I had used a drill half as thick as that which served in the operation; but when I made this discovery the work was already too far

Fig. 5.



advanced to be commenced again. Fig. 5 shows the present shape of the perforation. It is round and smooth, without exhibiting those circular furrows, which I have already ascribed to the action of a hollow drill. In order to complete the task in its fullest extent by producing a perfectly cylindrical hole, it would be necessary to remove,

by continued drilling, the projecting rim between the dotted lines: a labor probably requiring as much time as that hitherto consumed. I cannot say whether I shall have sufficient leisure and patience to perform it; for the present I am satisfied with the fact of having, perhaps, practically illustrated one of the methods of drilling employed during the age of stone. Of course, it would be rashness on my part to assert that the apparatus used by me had also served as a drilling implement in ancient Europe; yet the possibility cannot be denied, for just as the Iroquois invented it for producing fire, the ancient nations of Europe may have constructed it for another purpose. Mr. Desor thinks it probable that the drilling was effected by means of very thin flakes of flint fixed around a stick, which was made to turn in such a way as to separate a portion of the stone, which, when the perforation was accomplished, would fall to the ground.* A drilling-

Fig. 6.



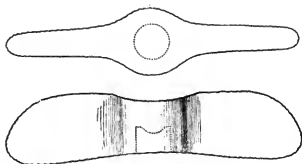
stick of this description really may have served for perforating soft stones, but could not be successfully applied to hard materials. I operated myself with such a drill on diorite, and found the flint flakes invariably break off after the first revolutions. Yet, whatever may have been the means employed in drilling stone in the pre-historic ages of Europe, it is certain that the carefully fashioned and pierced implements must have possessed a very high value in the eyes of their manufacturers. Some indication of this fact is offered by the occurrence of the edged halves of axes broken across the shaft-hole, which had been rendered serviceable again by a second perforation. A specimen of this kind, of which the annexed reduced sketch (Fig. 6) presents the upper view, is preserved in the Peabody Museum at Cambridge, Massachusetts. It was found

in northern Germany. The shaft-hole, which has been left in an unfinished state, evidently was formed by a solid drill. The material of this relic is variety of greenstone.

* Palafittes, &c., p. 359.

In North America the grooved tomahawk was, anterior to the occupation by Europeans, the prevailing implement of the axo-shape;* but pierced articles of this class also have been found, though not very frequently. Several are figured on page 218 of the "Ancient Monuments of the Mississippi Valley," by Squier and Davis. The material of most of those which I have seen is a rather soft stone of a greenish color, with darker veins or spots, capable of a fine polish. These perforated axes are mostly small, but very symmotrically shaped and highly finished. They were most probably worn on handles as badges of distinction by the superiors,† a supposition which gains strength from the fact that their material renders them unfit for real use. I know by experience that they occur from the Mississippi to the Atlantic coast. The peculiar stone of which they consist was also used for other objects, (the so-called gorgets, amulets, &c.,) and may have been an article of trade. The shaft-holes of these hatchet-like implements are exceedingly regular, and the annular striæ can often plainly be distinguished. They were doubtless produced by means of hollow drills, as will be seen hereafter. In addition to the perforated Indian axes just mentioned, there occur others, which are remarkable for being only pierced to a certain depth. It is true, I have not seen these latter very frequently, but in sufficient number to become convinced that the shaft-holes were purposely left in an unfinished condition. Their material is not the soft stone already referred to, but a harder substance, usually some kind of greenstone. They always present pretty much the same shape. The annexed half-size sketch (Fig. 7, upper and side view) shows the outline of one of these imple-

Fig. 7.



ments, which was found in western Massachusetts, and is now in the possession of Dr. Davis, of New York. The core at the bottom of the shaft-hole, which is indicated by dots, affords an indubitable proof that a hollow drill was employed. To render this implement serviceable for use, or even for show, a handle was driven as far as possible into the shaft-hole, and probably more firmly bound to

* Some ethnological writers, McNulloh and Schoolcraft, for instance, consider these stone axes as tools, and not as weapons; whereas it is most probable that they served both purposes, as occasion required. Men who were confined to the use of stone implements cannot be expected to have been very choice in their applications. A stone tomahawk, firmly attached to a withe, presented a very efficient battle-axe. Mr. Catlin gives, on plate 114 (vol. 2) of his well-known work, the portrait of *Mensonseah* (the Left Hand,) a Piankeshaw warrior, whom he represents with a helved stone tomahawk in his hand. Would this brave have allowed the artist to paint him thus accoutred, if he had not regarded his stone axe as a weapon? An Indian warrior, in his contempt for labor, certainly spurns the idea of being portrayed with a tool in his hand.

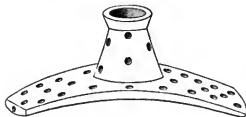
† Many of the perforated implements of Europe are supposed to have been destined for the same purpose.

the blade by ligatures. The depressions of the axe above and below the shaft-hole (observable in the side view) seem to have been destined for the reception of the fastening.

Yet, the manufactures of stone which evince the greatest skill of the former inhabitants of North America are by no means their pierced axes, but those remarkable pipes, often made of the hardest stones, that have been found in the so-called sacrificial mounds of the western States, but more especially in Ohio. These "mound pipes" usually represent bowl and tube in one piece, thus differing from the modern Indian pipe, which consists of a bowl and a long wooden stem, and bears a distant resemblance to the *chibouc* of the Turks. A great number of pipes of the above-mentioned antique shape were disinterred by Messrs. Squier and Davis during their survey of the ancient earth-works in the Mississippi valley, and are described and figured in their work already quoted by me, which forms the first volume of "Smithsonian Contributions to Knowledge."*

The accompanying cut (Fig. 8) presents the outline of the mound-pipe in its

Fig. 8.



simple or primitive form.

The drawing is about half the size of the original, which was exhumed with many similar articles from a mound near Chillicothe, Ohio, and belonged formerly to the collection of Dr. Davis. It will be seen that the bowl rises from the middle of a flat and somewhat curved base, one side of which communicates by

means of a narrow perforation, one-sixth of an inch (about four millimeters) in diameter, with the hollow of the bowl, and represents the tube, or rather the mouth-piece of the pipe, while the other unperforated end forms the handle by which the smoker held the implement and approached it to his mouth. Bowl and base are ornamented with small cup-shaped holes. This pipe consists of hard porphyry, and is wrought from a single piece, like all others of similar character. I have already stated that it may be considered as the simple or typical form of this class of implements. In the more elaborate specimens the bowl is formed in some instances in imitation of the human head, but generally of the body of an animal; and in the latter cases the peculiar characteristics of the species which have served as models, comprising mammals, birds, and amphibia, are frequently expressed with surprising fidelity; a modern artist, indeed, notwithstanding his far superior instruments, would find no little difficulty in reproducing the more finished of these objects, especially when carving them from porphyry, which was the kind of stone chiefly employed by the manufacturers. It must be borne in mind that the real use of metal was unknown to the ancient populations of North America. Implements and ornaments of copper, it is true, have been discovered, to a limited extent, in the mounds of the western States, and elsewhere, but the copper thus employed has not been obtained by the reduction from its ores; on the contrary, it is evident that the aborigines fashioned those articles from pieces of *native* copper, which they brought into the required shape by the simple process of hammering. They obtained the copper from the southern shore of Lake Superior, where extensive traces of their rude mining operations are still

* The originals are now in the Blackmore Museum, at Salisbury, England, an institution of recent origin, to which Dr. Davis sold his excellent collection of Indian relics, mostly obtained during the survey to which I have alluded. Before the sale took place, I had constantly occasion to see the collection, and thus became familiar with the character of the specimens.

to be seen.* This hammered native copper is so soft that it can easily be out with a knife, and therefore cannot have furnished the implements for working those hard mineral substances, which, indeed, successfully resist well-tempered steel. As a consequence, it must be presumed that the manufacturers of the pipes performed their work in the most tedious and painful manner, by rubbing the stone and grinding it with sharp sand and water, although this method leaves many details in the execution of their productions unexplained. In viewing, for example, their figures of birds, it is difficult to comprehend how they succeeded in representing the feathers, which are indicated by steady and boldly cut lines, straight and curved, in close imitation of nature.† The perforations and hollows of the mound-pipes are drilled with perfect accuracy, showing at once that the implement which produced them was not merely turned between the hands, but moved by an apparatus which coincided, in all probability, with the bow-drill still used by watchmakers and other artisans. The latter, it is well known, consists of a straight drill, which passes through the centre of a disk grooved at the periphery and revolves around two fixed points, one of them being formed by the boro. Motion is imparted by means of a bow, the string of which encircles the disk. It certainly would appear hasty to attribute to the aborigines of North America a knowledge of this implement, if it were not for the circumstance that there occur among the relics of the former population rings of stone and bone which are almost identical with the disks just mentioned, and most probably have served the same purpose. In fact, it is almost impossible to assign them any other destination. These rings are of various sizes, but similar in shape, being deeply grooved upon the outer edge, and pierced by eight equidistant small holes radiating from the centre.‡ Fig. 9 is a full-sized drawing of one which was discovered in a mound on the north fork of Paint creek, about six miles distant from Chillicothe, Ohio. The sketch, however, represents the object as perfect, whereas the original, formerly belonging to Dr. Davis, constitutes only one-half of the ring, which consists of a dark stone of medium hardness. The character of the rings encourages me to attempt the restoration of the an-

Fig. 9



* Only the inhabitants of Mexico, and some countries in the southern portion of the American continent, understood the manufacture of bronze. It will hardly be necessary to add that iron was altogether unknown to the natives of America until Europeans taught them its use.

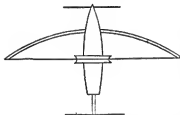
† The amount of labor bestowed upon the manufacture of these specimens must have been enormous, considering the time it is said to have required for fashioning articles of a much simpler character. According to Lafitau a North American Indian sometimes spent his lifetime in making a stone tomahawk, yet without entirely finishing it. *Lafitau, Mœurs des Sauvages Américains, Paris, 1724, vol. 2, p. 110.*

‡ Mr. Wallace has found that plain cylinders of imperfect rock crystal, four to eight inches long, and one inch in diameter, are made and perforated by very low tribes on the Rio Negro. They are not, as Humboldt seems to have supposed, the result of high mechanical skill, but merely of the most simple and savage processes, carried on with that utter disregard of time that lets the Indian spend a month in making an arrow. They are merely ground down into shape by rubbing, and the perforating of the cylinders, crosswise, or even lengthwise, is said to be done thus: A pointed flexible leaf-shoot of wild plantain is twirled with the hands against the hard stone, till, with the aid of fine sand and water, it bores into and through it, and this is said to take years to do. Such cylinders as the chiefs wear are said sometimes to take two men's lives to perforate. The stone is brought from a great distance up the river, and is very highly valued."—*Taylor, Researches, &c., p. 187.*

§ Ancient Monuments of the Mississippi Valley, p. 224.

cient Indian bow-drill, which may have presented the shape indicated by Fig. 10.

Fig. 10.



The ring, it seems, encircled a massive drill-holder, to which it was fastened by pegs driven through the holes on its periphery. Their purpose is thus fully explained.

May not an apparatus of similar construction also have been known in Europe during the bronze age, and even at an earlier period? In using the pump-drill, described and figured by me, constant oscillations of the shaft, tending to enlarge the bore, cannot be avoided; but they are altogether obviated when,

as in Fig. 10, the upper end of the shaft or drill-holder revolves around a fixed point. And further, may not in Europe as well as in America the latter more perfect apparatus have superseded, in the course of time, the simpler contrivance with which I have experimented? This view will not appear strange, considering that man in all parts of the globe progressed slowly, and that every new development of ingenuity was based upon the results of former experience.

The greater number of drilled Indian implements which I had occasion to examine bore the unmistakable marks of having been perforated with hollow drills; yet I have also seen Indian performances in drilling indicating the application of solid implements. As an illustration I annex (Fig. 11, full size) the

Fig. 11.



drawing of a pipe consisting of almost transparent rock crystal, which was taken from a mound near Bainbridge, Ross county, Ohio, and is now the property of Dr. Davis. Its shape, it will be observed, is that of a barrel somewhat narrowing at the bottom; it is regularly formed and highly polished. I left the drawing purposely without shading in order to indicate the two hollows, of which the upper one served as the receptacle for the smoking material, while that which meets it from the side was destined for the insertion of a stem. The terminations of the hollows are rounded, and consequently have been drilled with a solid implement.

It is very likely that the hollow drills of the aborigines of North America were pieces of that hard and tough cane (*Arundinaria macrosperma*, Michaux,) which grows abundantly in the southern part of the United States, mostly along the banks of large rivers, and forms at present an article of trade, being used for pipe-stems and fishing-rods. This cane varies considerably in thickness; sometimes as thin as a straw, it assumes, when fully grown, the diametral proportions of a strong rifle-barrel, and even of larger cylindrical objects, in which cases it reaches the enormous height of 25 or 30 feet. A piece of this cane, from which the knotty joints have been cut, forms a regular hollow cylinder sufficiently strong to serve as a drill. I learned from Dr. Davis that many years ago a stone pipe with an unfinished hollow, partly filled with vegetable matter, was sent from Mississippi to the late Dr. Samuel G. Morton, of Philadelphia. When subjected to a microscopical examination the vegetable substance exhibited the fibrous structure of cane, and thus appeared to be the remnant of a drill broken off in the bore. It is, however, my intention to try the applicability of this cane by drilling experiments.

In conclusion, I will observe that the more finished stone articles of the former inhabitants of North America, and especially the pipes from the mounds, are

perhaps the best specimens of art left by any people to whom the use of metal was unknown, and that in examining the archaeological collections of Europe, I have seen no objects produced under similar circumstances which display an equal degree of skill in the art of fashioning stone.



Ancient Stone Axes from North Germany.









